COST MODEL EQUATIONS USED IN THE UNIT COST ESTIMATOR

A. DATA ENTRY

Prompt user to enter data for the following (all fields shall initially contain default values):

Variable	Variable Definition	Default Value	Units
Op	Operating Hours per Day	16	hr/day
DRE	Destruction Removal Efficiency	0.98	%
DFR	Design Flow Rate	3,000	cfm
Cont	Contaminant Concentration	2,000	ppm
Gas	Natural Gas Cost	0.715	$/therm
MW_{cont}	Molecular Weight of Contaminant	100	
MW_{air}	Molecular Weight of Air	29	
MW_{water}	Molecular Weight of Water	18	
Electric	Electrical Cost	0.10	$/kwhr
Water	Water Cost	3.00	$/100 cu. ft.
Sewer	Sewer Cost	3.68	$/100 cu. ft.
Manifest	Manifest Cost	125	$/drum
$Labor_{tech}$	Technician Labor Cost	37	$/hr
$Labor_{eng}$	Engineer Labor Cost	50	$/hr

B. CALCULATED PARAMETERS

DRE_{adj} = IF(DRE>=0.98,0.98,DRE). In other words, (If DRE entered >= 0.98, *true*: DRE_{adj} =0.98, *false*: DRE_{adj} = DRE entered)

TWA (ppm) = [Cont * 75 +(Cont + 200)/2*50 + 200 * 240]/365

$Cont_{non\text{-}adsorption}$/year = (TWA/1,000,000) * DFR * 1,440 * MW_{cont}/MW_{air} * 0.075

* DRE * Op/24 * 365

$Cont_{non\text{-}adsorption}$/day = ($Cont_{non\text{-}adsorption}$/year)/365

$Cont_{adsorption}$/year = (TWA/1,000,000) * DFR * 1,440 * MW_{cont}/MW_{air} * 0.075

* DRE_{adj} * Op/24 * 365

$Cont_{adsorption}$/day = ($Cont_{adsorption}$/year)/365

Drums (# /day) = ($Cont_{adsorption}$/year)/(62.4 * MW_{cont}/MW_{water}) * 7.48/55/365

Steam (lb/day) = 3 * $Cont_{adsorption}$/day

H2O (cu. ft./day) = Steam/62.5

Desorb (drums water/day) = H2O * 7.48/55

C. CAPITAL COST CALCULATION

1. Installation

For Thermal Oxidation, Plasma Destruction, Photocatalytic Oxidation (system), Fluidized Bed Adsorption with PDU (system), Alkali Bed Reactor:

Capital $Cost_{DFR}$ = capital $cost_{3000}$ + 0.35 * capital $cost_{3000}$ * (DFR – 3000)/3000

where: Thermal Oxidation: capital $cost_{3000}$ = $256,830

Plasma Destruction: capital $cost_{3000}$ = $431,830

Photocatalytic Oxidation: capital $cost_{3000}$ = $359,400

Fluidized Bed Adsorption with PDU: capital $cost_{3000}$ = $414,489

Alkali Bed Reactor: capital $cost_{3000}$ = $365,000

For Catalytic Thermal Oxidation:

Capital $Cost_{DFR}$ = capital $cost_{3000}$

+ 0.35 * (capital $cost_{3000}$ – catalyst $frame_{3000}$) * (DFR – 3000)/3000

+ $37,000$_{per 1000 cfm}$ * (DFR – 3000)/1000

where: capital $cost_{3000}$ = $359,400

catalyst $frame_{3000}$ = $111,000

For Flameless Thermal Oxidation:

Capital $Cost_{DFR}$ = capital $cost_{3000}$

+ 0.35 * (capital $cost_{3000}$ – bed $material_{3000}$) * (DFR – 3000)/3000

+ $25,000_{per\ 1000\ cfm}$ * (DFR – 3000)/1000

where: capital $cost_{3000}$ = $415,000

bed $material_{3000}$ = $75,000

For Vapor Phase Adsorption (Fluidized Bed Adsorber system):

Capital $Cost_{DFR}$ = capital $cost_{3000}$ + 0.35 * (capital $cost_{3000}$ – beaded $media_{3000}$) *

(DFR – 3000)/3000 + beaded $media_{3000}$ * (DFR – 3000)/1000

where: capital $cost_{3000}$ **=** $425,000

beaded $media_{3000}$ = $4,950

2. **Mobilization/Demobilization**

For each technology/system:

Mob = (300 * $Labor_{tech}$ + 40 * $Labor_{eng}$) + (150 * $Labor_{tech}$ + 20 * $Labor_{eng}$)

3. **Total Capital Cost**

For each technology/system:

$Total_{cap}$ = Capital $Cost_{DFR}$ + Mob

D. O&M COST CALCULATION

1. **Natural Gas**

For Thermal Oxidation:

NG_{TO} = 7,000,000 * Op/100,000 * Gas * DFR/3,000

For Catalytic Thermal Oxidation:

NG_{CTO} = 3,000,000 * Op/100,000 * Gas * DFR/3,000

For Flameless Thermal Oxidation:

NG_{FLO} = 4,400,000 * Op/100,000 * Gas * DFR/3,000

For Vapor Phase Adsorption (Fluidized Bed Adsorber system), Fluidized Bed with PDU system:

NG_{AD} = Steam * 1,164/100,000 * Gas/0.8

For Photocatalytic Oxidation:

Not Applicable (value = 0)

For Alkali Bed Reactor:

NG_{ALK} = NG_{CTO} * (662-60)/(900-60)

For Plasma Destruction:

Not Applicable (value = 0)

2. **Electricity**

For Thermal Oxidation, Catalytic Thermal Oxidation, Flameless Thermal Oxidation:

E_{OX} = 50 * Op * Electric * DFR/3,000

For Vapor Phase Adsorption (Fluidized Bed Adsorber system), Alkali Bed Reactor:

E_{AD} = 60 * Op * Electric * DFR/3,000

For Photocatalytic Oxidation:

E_{PCO} = 3,000 * 3 * 2 * 2 * (Cont – 100)/400/365 * Electric/0.07 * DFR/3,000

For Plasma Destruction:

E_{PLM} = ($Cont_{non\text{-}adsorption}$/day)/2.205 * 10 * Electric + 50 * Op * Electric

For Fluidized Bed Adsorption with PDU (system):

E_{UV} = 118,973 * Electric/0.07 * ($Cont_{adsorption}$/day)/95479

3. **Water**

For Thermal Oxidation:

W_{TO} = 90 * (Water + Sewer)/7.48/100 * Op * 60 * DFR/3,000

For Catalytic Thermal Oxidation:

W_{CTO} = 48 * (Water + Sewer)/7.48/100 * Op * 60 * DFR/3,000

For Flameless Thermal Oxidation:

W_{FTO} = 70 * (Water + Sewer)/7.48/100 * Op * 60 * DFR/3,000

For Vapor Phase Adsorption (Deep Bed Adsorber system), Fluidized Bed Adsorption with PDU (system):

W_{AD} = H2O/100 * (Water + Sewer)

For Photocatalytic Oxidation:

W_{PCO} = 10 * 60 * Op/7.48/100 * (Water + Sewer) * DFR/3,000

For Plasma Destruction:

W_{PLM} = 10 * 60/7.48/100 * Op * (Water + Sewer) * DFR/3,000

For Alkali Bed Reactor:

W_{ALK} = $Cont_{non\text{-}adsorption}$/day * 10/62.4/100 * (Water + Sewer) * DFR/3,000

4. pH Control

For Thermal Oxidation, Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor:

$$PH_{OX} = 350/2{,}000 * Cont * DFR/3{,}000$$

For Fluidized Bed Adsorption with PDU (system):

$$PH_{PTI} = 14844 * Electric/0.07 * (Cont_{adsorption}/year)/95479/365$$

For Vapor Phase Adsorption (Fluidized Bed Adsorber system):

Not Applicable (value = 0)

5. **Manifest**

   For Thermal Oxidation, Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Fluidized Bed Adsorption with PDU (system), Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor:

   Not Applicable (value = 0)

   For Vapor Phase Adsorption (Fluidized Bed Adsorber system):

   $$MF_{FAD} = Drums * Manifest$$

6. **Monitor & Preventive Maintenance (Labor, $/day)**

   For Thermal Oxidation:

   $$MPML_{TO} = 1 * Labor_{tech}$$

   For Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Fluidized Bed Adsorption with PDU (system), Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor, Vapor Phase Adsorption (Fluidized Bed Adsorber):

   $$MPML_{TO} = 2 * Labor_{tech}$$

7. **Monitor & Preventive Maintenance (Material, $/day)**

   For Thermal Oxidation:

   $$MPMM_{TO} = 45$$

For Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Fluidized Bed Adsorption with PDU (system), Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor:

$MPML_{OX} = 50$

For Vapor Phase Adsorption (Fluidized Bed Adsorber system):

$MPML_{AD} = 66$

8. **Unscheduled Maintenance (Labor, $/day)**

For Thermal Oxidation:

$UML_{TO} = 0.5 * Labor_{tech}$

For Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Fluidized Bed Adsorption with PDU (system), Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor, Vapor Phase Adsorption (Fluidized Bed Adsorber):

$UML_{OT} = 1* Labor_{tech}$

9. **Unscheduled Maintenance (Material, $/day)**

For Thermal Oxidation, Flameless Thermal Oxidation:

$UMM_{OX} = 5$

For Catalytic Thermal Oxidation, Fluidized Bed Adsorption with PDU (system), Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor, Vapor Phase Adsorption (Fluidized Bed Adsorber):

$UMM_{OT} = 10$

10. **Management**

For Thermal Oxidation:

$$MGT_{OX} = 1* Labor_{eng}$$

For Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Fluidized Bed Adsorption with PDU (system), Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor, Vapor Phase Adsorption (Fluidized Bed Adsorber):

$MGT_{OT} = 2* Labor_{eng}$

11. Daily Operating Cost ($/day)

For each technology:

Daily = sum of Items D1 through D10 above for each respective technology.

12. Annual Operating Cost ($/year)

For each technology:

$Annual_{op}$ = cost $/day * 365

E. SUMMARY CALCULATIONS

1. Amortized Capital Cost

For Vapor Phase Adsorption (Fluidized Bed Adsorber system):

Amortize Capital Cost assuming 10 years at 8% interest, or

$Amortize_{cap} = PMT(0.08,10,Total_{cap})$

For Thermal Oxidation, Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Fluidized Bed Adsorption with PDU (system), Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor:

Amortize Capital Cost assuming 5 years at 8% interest, or

$Amortize_{cap} = PMT(0.08,5,Total_{cap})$

2. Contaminant Removed (lbs)

For Thermal Oxidation, Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor:

$Removed_{OX} = Cont_{non\text{-}adsorption}$/year

For Vapor Phase Adsorption (Fluidized Bed Adsorber system), Fluidized Bed Adsorption with PDU (system):

$Removed_{OT} = Cont_{adsorption}/year$

3. **$/lb of Contaminant Removed**

For Thermal Oxidation, Catalytic Thermal Oxidation, Flameless Thermal Oxidation, Photocatalytic Oxidation (system), Plasma Destruction, Alkali Bed Reactor:

$$\$/lb = (Amortize_{cap} + Annual_{op}) / Removed_{OX}$$

For Vapor Phase Adsorption (Fluidized Bed Adsorber system), Fluidized Bed Adsorption with PDU (system):

$$\$/lb = (Amortize_{cap} + Annual_{op})/ Removed_{OT}$$